Weed Control Research: Past, Present, and Future
Author(s): A. S. Crafts
Reviewed work(s):
Source: *Weeds*, Vol. 8, No. 4 (Oct., 1960), pp. 535-540
Published by: Weed Science Society of America and Allen Press
Stable URL: http://www.jstor.org/stable/4040353
Accessed: 11/03/2013 15:49

Weeds

JOURNAL OF THE WEED SOCIETY OF AMERICA

VOLUME 8 OCTOBER 1960 NUMBER 4

Weed Control Research—Past, Present, and Future[1]

A. S. CRAFTS[2]

THE new scientific discipline, weed control, is the product of research. So long as man has grown crops for his own personal use, he has fought weeds, for nature favors community life for her plants. True there are examples of pure cultures of plants in nature; the white pine forests of the northwest, the buffalo grass prairies, wild rice in the northern lakes. But by and large, the areas now devoted to our major crops, wheat, corn, cotton and forage, were occupied by mixed plant populations and now they are in monoculture or in controlled plant populations and this nature abhors. Hence through the ages and even more today the farmer has been at war with weeds, the invaders of his crops.

But now the mode of warfare is changed. At last man has devised tools for combatting weeds, commensurate with the tools he uses for mining and manufacture and travel; modern mechanical and chemical tools; and these, I repeat, are the products of research.

Before I be accused of boasting I hasten to add that, as in all fields of research, many of the key discoveries in chemical weed control have come about by chance. When Bonnet, in the final years of the past century, observed that copper salts, applied to mixed plant populations, killed broad-leaved weeds without harming cereals, he was using Bordeaux spray to combat disease on his grape vines. Almost simultaneously and apparently by chance Schultz in Germany and Bolley in America found that strong salt and acid solutions would bring about this same result. The point I wish to make is that while these discoveries were apparently chance observations, they had to happen.

The stage was set; Liebig had elaborated his chemical theory of the nutrition of plants and proposed that plants obtain their nitrogen from the air as ammonia; Lawes had controverted this claim; chemists, and farmers, and amateur naturalists around the world

[1]Presidential Address, Weed Society of America, Denver, Colorado, February 23, 1960.

[2]Retiring President, WSA: Chairman, Department of Botany, University of California, Davis.

were playing with chemicals and plants. The fact that three, and possibly more, independent observations of the selective killing of weeds in cereal crops occurred almost simultaneously, was evidence that scientific agriculture had evolved to the place where differential wetting of mixed plant populations by toxic solutions had to be noted by someone. And so we may ask, was this in fact a chance discovery?

Following a brief flurry of interest, chemical control of weeds in cereal crops reverted to a slow and steady growth in Europe where grain growing was intense. By trial and error it was found that many salts and acids may serve as selective herbicides to kill broad-leaved weeds in cereal crops; examples are copper sulfate, copper nitrate, iron sulfate, sodium arsenite, and sulfuric acid. Through the years, because of economic factors, sulfuric acid emerged as the principal chemical used for this purpose, and a number of other crops including flax, peas and onions, were found to be amenable to selective weed control.

In America after some 12 years of experimentation Bolley published an Experiment Station Bulletin in North Dakota in which he said "When the farming public has accepted this method of attacking weeds as a regular farm operation, the gain..... will be much greater.....than that which has been afforded by any other single piece of investigation applied to field work in agriculture." Bolley had caught the vision, but like so many other scientists he was ahead of his time. While making slow but steady progress in Europe, selective control of weeds by chemical means languished in America. The concept was valid but the tools did not fit the job. And farmers in this expanding, pioneering agriculture were not interested.

At this point I should pay tribute to some of the pioneers of Europe. Morettini in Italy, Rabate in France, and Korsmo in Norway forged ahead applying new knowledge and new technics. In 1932 Korsmo published a monumental work in which he produced irrefutable evidence for yield increases in wheat, barley and oats following use of selective weed sprays. A survey of 211 experiments over an eight year period showed an average yield increase of 25 percent for sprayed plots over unsprayed. Sulfuric acid gave generally superior results although spraying with iron sulfate and nitric acid and dusting with kainite and calcium cyanamide was done.

The teen years of the twentieth century brought the next two important discoveries. In 1917 George P. Gray published in a California Agricultural Experiment Station Bulletin the observation that a dilute solution of sodium arsenite sprayed on bindweed within the fogbelt of coastal California, would kill the roots to a depth of several feet. This introduced the concept of translocated herbicides. I believe that Gray had this possibility in mind when he designed his experiments.

The second discovery was the chance observation that, when carbon bisulfide was applied as a soil fumigant in vineyards to control the root-borne disease *Phylloxera,* bindweed growing in the treated areas was killed. Soil fumigation for controlling deep-rooted perennial weeds soon became a general practice. In this connection the careful experiments of Rogers and Hatfield published in 1929 in a Colorado Agricultural Experiment Station Bulletin should be mentioned. They placed soil fumigation for the purpose of killing weeds on a sound quantitative basis. Later work by Hagan and Hanneson at Davis emphasized the effects of soil structure and soil composition on the distribution of fumigants.

I do not know how sodium chlorate was first found to be a weed killer. During the early 1920's it was used to control vegetation along railroad rights-of-way in Germany and in 1926 Åslander reported experimental use of this herbicide in this country; he published more data in 1928. Although Åslander had discussed the fact that chlorate is effective applied through the soil, later workers used the chemical as a foliar spray apparently unaware of its effectiveness through the soil. By the middle 30's experimental work had proved that chlorates may kill leaves by contact action; that under proper conditions they may penetrate leaves, enter the xylem and move into roots, by reversal of the transpiration stream; that, when applied to the soil and leached in, they may be absorbed by roots resulting in death of the plants; and that when present in plants in sublethal concentration they may bring about a chlorotic, stunted growth of foliage from which the plant may recover; a common result of the presence of chlorates in plants is a reduction in their starch content.

Meanwhile field testing had proved the great toxicity of sodium arsenite to plant foliage and this material became the standard weed spray throughout this and many other countries. And tests in California showed that an acidified solution of sodium arsenite, applied to deep-rooted perennial weeds under proper conditions would penetrate the foliage, enter the xylem and move deep into the roots. This acid-arsenical spray, a modification of George Gray's original material, became quite widely used in the Western United States and in Australia. Careful plant physiological research was utilized in developing this method to its maximum effectiveness.

Pastac in France discovered that sodium dinitrocresylate would selectively kill broadleaved weeds in cereals in 1933; four years later this chemical was introduced into the United States and tested widely. And in 1939 a curious Oregon farmer, wishing to fertilize his grain crop and kill weeds at the same time, found that addition of ammonium sulfate to the dinitrocresylate spray greatly enhanced its toxicity. Thus activation of dinitro compounds was discovered by chance. The chemical mechanism of this activation was worked out and published in 1945; it was effective not only on dinitro compounds but on sodium pentachlorophenate as well.

I do not need to describe the introduction of 2,4–D in 1944 as you are all familiar with that story. It is interesting to note, however, that the first publication on this compound as a weed killer in America described its use as a translocated spray on bindweed and in Britain it was first used as a selective soil sterilant. Only after its public introduction was its use as a selective spray in cereal crops discovered; use by the low-volume method followed soon after tests by MacDonald of the Peevey Co. carried out in California. MacDonald proved that application in a volume of 6 gallons of spray liquid per acre was as effective as in 160 gallons. Thus, for the first time, a chemical weed control method that was cheap, effective, and practical for large scale application became available. Within a year acreage treated with herbicides increased from a few thousand to several million; chemical weed control became a going business.

Meanwhile careful research was developing a body of data related to the toxicity of herbicides in soils, and the effects of soil factors on their availability to plants. Again the stage was set so that when Anderson and Ahlgren and Anderson and Wolf announced the successful use of 2,4–D as a pre-emergence application in corn, this method was immediately recognized as a new breakthrough in the chemicalization of agriculture. Tillage for weed control, abandoned since the 30's by certain citrus growers in California was now dispensable in the growing of corn and other row crops. A true revolution was at hand.

I need not dwell on the announcement of IPC by the group working at Camp Dietrick, of chloro IPC by Freed in Oregon, of endothal by the Sharples Company, Alanap and MH by Naugatuck, of the substituted ureas by duPont, the chloroacetamides by Monsanto, of the thiol and dithiocarbamates, the symmetrical triazines, of amino triazole and dalapon and chlorobenzoic acids and the great numbers of analogues of 2,4–D by chemical companies in this country and abroad. You have all lived through these exciting years; the methods of synthesis, screening, and testing are familiar; millions of man-hours are being consumed and millions of dollars spent in this search for new and better chemical agents. But, what about research?

It will be years before the plant physiologists and biochemists can possibly work out the mechanisms of absorption, translocation and lethal action of the chemicals we now have on hand. The new methods of autoradiography, counting, and chromatography are greatly speeding our work and still we lag away behind. We know that herbicides may penetrate the cuticle and that under other conditions they may enter the leaves via an aqueous route. We know that stomatal penetration is effective but not necessary, and that it cannot be depended on for all absorption. We know that some herbicides enter the symplast, move into the phloem and translocate with foods to sinks in roots and shoot tips, flowers and fruits; others enter only by roots and move to tops in the transpiration stream. We know that some herbicides act as mitotic poisons on meristematic cells, others uncouple the respiration mechanism, some are transformed to toxic forms by beta oxidation, some inhibit the Hill reaction, some interfere with pantothenate metabolism.

But the true selective mechanism of 2,4–D is still obscure; we don't know that the blocking of the photolysis of water is the whole mechanism of action of the ureas and triazines; the mechanism of toxic action of the chlorobenzoic acids is not understood, for these compounds are apparently not used up in the killing process.

Much of this research will have to be accomplished in Universities and government supported laboratories for only in these does the proper environment for basic research exist. Few chemical companies can afford the research necessary to a complete understanding of the action of the compounds they produce; their laboratories are under too much pressure for immediate answers to allow for the quiet, contemplative type of study required to solve these problems.

And so our new discipline of weed control must span the hurried torrent of modern chemical discovery, providing information in the diverse fields of synthetic chemistry, phytopharmacy, plant physiology, plant biochemistry, agronomy, horticulture and economics. Is it any wonder that Warren Shaw has a furrowed brow, that Dr. Willard needs help to get our journal out on schedule, and that Fred Slife needs a sabbatical leave?

Well, so much for modern research in weed control.

Some of you may feel that I have spent too much time dwelling on the "glories of the past." You say "the past is dead, we live in the present, what about the future?" To you I reply that I have not been merely reporting. What I am saying is that the present is born out of the past and that the future depends on both. Our discipline was not born over-night. It is not just a collection of chance discoveries. Weed control did not start in 1944 with the discovery of 2,4–D. With all due respect to Kraus and Templeman and Sexton and Blackman, we must remember that Darwin observed the turning of the oat coleoptile toward the light in 1880; Went proved the existence of the plant hormone in 1926; Zimmerman and Hitchcock synthesized and tested 2,4–dichlorophenoxyacetic acid and many of its analogues in 1942. While the discovery of the herbicidal action of 2,4–D came about in America as the result of the stimulating atmosphere of war, in Britain the concept of the absolute hormonal control of plant growth had arrived some years before. The herbicidal properties of 2,4–D could not have remained in obscurity for a single year in the upsurge of plant physiological research that followed the war. This was a concept that had to be born. Considering the mass of basic research on cell physiology, plant biochemistry and hormone mechanism that was accumulating, the discovery of the herbicidal properties was inevitable. Like the discovery of atomic fission and antibiotics the sum total of knowledge of plant response to growth regulating chemicals had grown to a state where a major advance in the area of plant control was overdue.

And so with many of the other concepts that are coming from our present research. Biochemists have worked out the details of the respiration cycles; discover a chemical that blocks any step in these complex processes and you have a potential herbicide. Hundreds of plant enzymes are now known; find a chemical that interferes with the smooth function of any of these and you have a potential herbicide. Antiauxins, super auxins, antimetabolites, protein coagulants, simulated viruses, these and a hundred other types of compounds offer promise; these are the modern reagents to use; they constitute the tools of the present day weed researcher.

What of the future? I'm afraid that many of you will be disappointed in my answer, for I am not a crystal ball gazer. I have no fears for the future of our new discipline. I already see piled up problems that will keep most of us busy for years. I will close by quoting the answer that I habitually give to question No. 6 on our O. E. S. form 8, the annual report on our Experiment Station Project. To the question "Work planned for next year", I always reply, "Studies on the uptake, distribution, and mode of action of herbicides will be continued."